Fisheries and Climate Toolkit

Supporting climate-ready, resilient and sustainable fisheries

https://fisheriesclimatetoolkit.sdsu.edu/

Becca Lewison (SDSU) and Cam Braun (WHOI)

NOAA COASTWATCH WEST COAST REGIONAL NODE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

EcoCast

EcoCast Product | EcoCast Explorer | About EcoCast

Photo copyright: Mark Conlin

A Eco-Informatic Tool for Fisheries Sustainability

What is EcoCast?

EcoCast is a fisheries sustainability tool that helps fishers and managers evaluate how to allocate fishing effort to optimize the sustainable harvest of target fish while minimizing bycatch of protected or threatened animals.

View details »

Finding a good place to fish

The EcoCast Product combines the predicted distributions of target catch species and bycatch species into a single map that suggests better and poorer locations to fish off the US West Coast.

View the map »

Scenario analysis

EcoCast Explorer gives users an opportunity to run scenario analyses to explore how the EcoCast product works. Users are able to generate predictive maps for specific dates, for single species, and can change the species weightings. This tool gives users the ability to explore how species are responding to changing ocean conditions, and how that can influence the EcoCast Product.

Run Analyses »

https://coastwatch.pfeg.noaa.gov/ecocast/

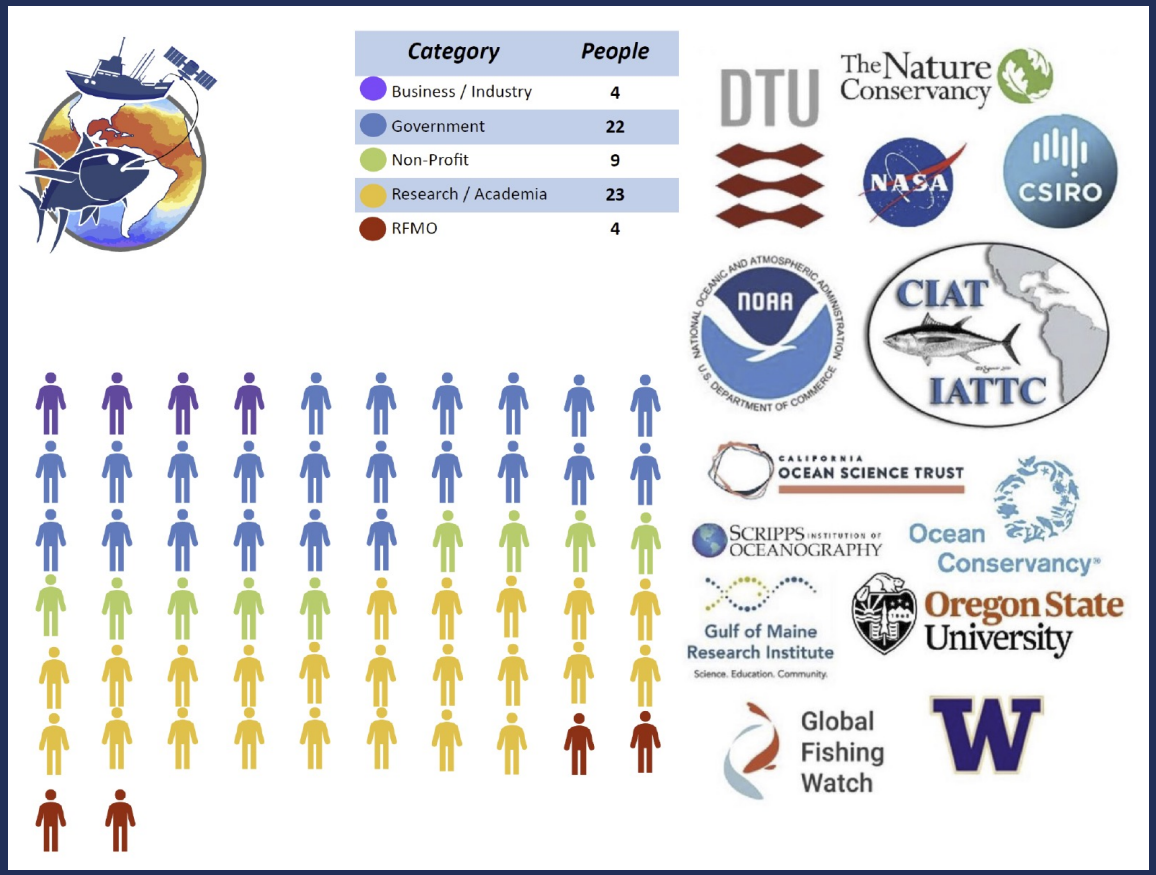
- **Forecasting species and vessel dynamics** - Identifying factors that influence climate projections of species and vessel dynamics.

- **Tracking magnitude/velocity of change** - How quickly are projected changes likely to occur in species and vessels? How can historical data help us characterize the likely changes across the near and far future?

- **Harnessing big data and data pipelines** - How can state of the art computational infrastructure and more creative data uses help us improve dynamic modelling?

- **Climate change uncertainty in a fisheries context** - Capturing and communicating climate uncertainty for fisheries stakeholders is **mission critical**. We aim to improve how stakeholders understand and interpret uncertainty

Stakeholder engagement and communication



Accessible, online products

Relevant/timely data viz

Build and expand capacity

Target 14.2 Improve mgmt./resilience

- **Indicator 14.2.1 – Ecosystem based management**

Target 14.4 Support science-based harvest

- **Indicator 14.4.1 – Sustainable harvest**

Photo: Jeff Muir


Rebecca Lewison


Camrin Braun


Kathy Mills


Elliott Hazen


Stephanie Brodie


Heather Welch


Nima Farchadi


Andrew Allyn


Riley Young-Morse

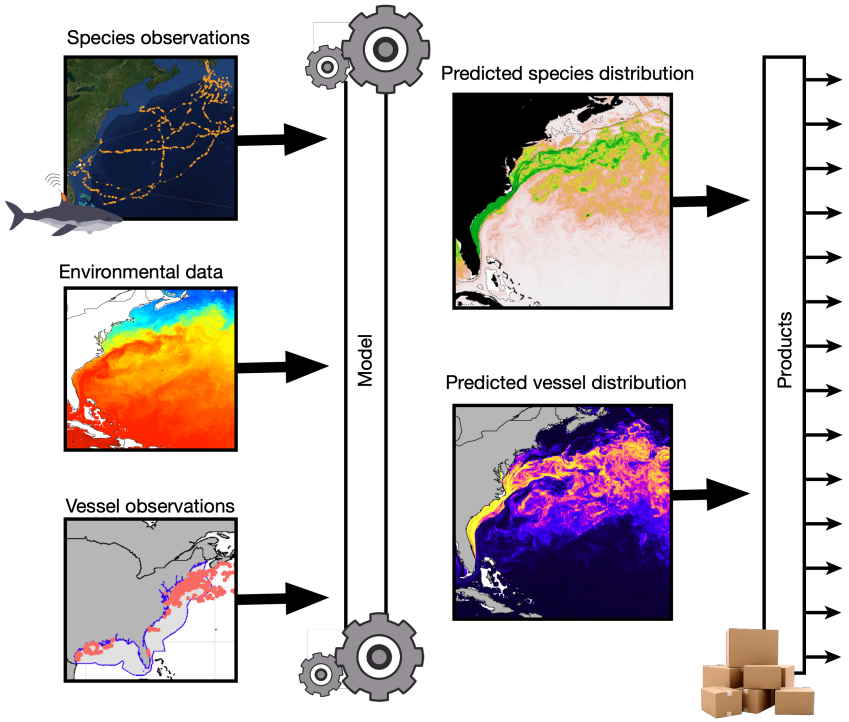

Alex Kerney


Dylan Pugh

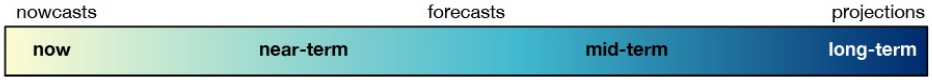

Nerea Lazama Ochoa

Stephen Bograd

What's under the hood



Applications



Identify bycatch "hotspots"

Compare gear/fishery agnostic modeling approaches

Inform adaptive management strategies

Track fishery-relevant physical and biological oceanography

Inform actionable management recommendations

Assess closure efficacy and alternative designs

Quantify closure benefit / opportunity cost

Identify novel bycatch & non-target interactions

Identify fishery-relevant climate anomalies

Quantify & communicate uncertainty

Integrate climate projections into essential habitat

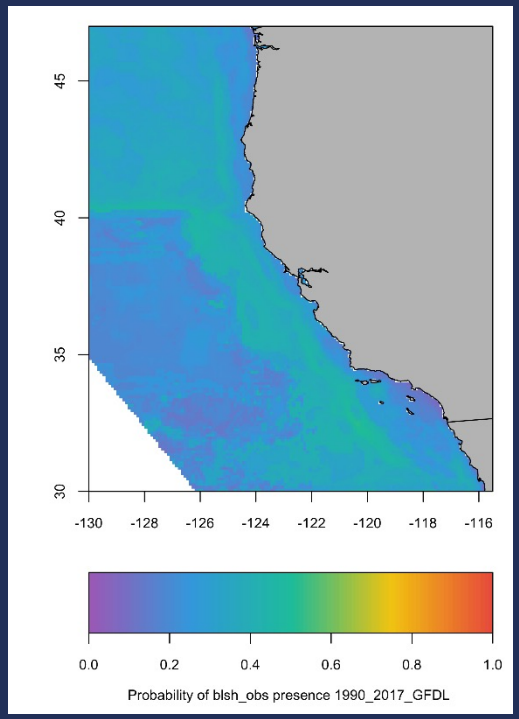
Assess future of the fisheries

Track changing vessel & species distributions

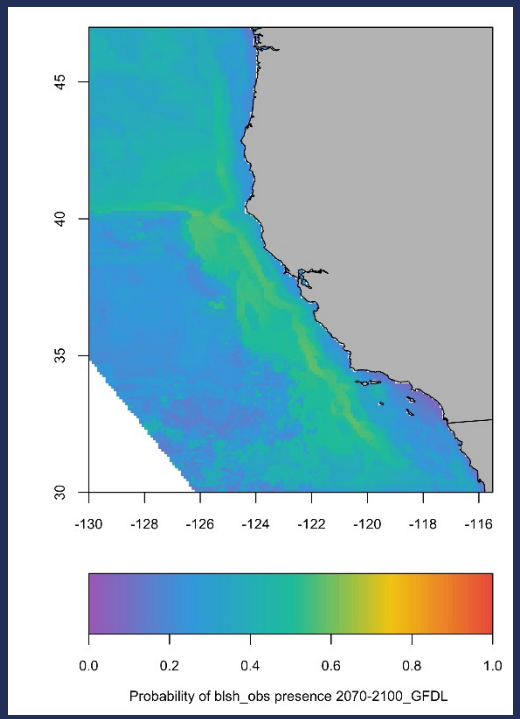
Reduce non-target and discard interactions

Forecasting species dynamics: climate change in the CCS

1990-2017-GFDL



2070-2100-GFDL



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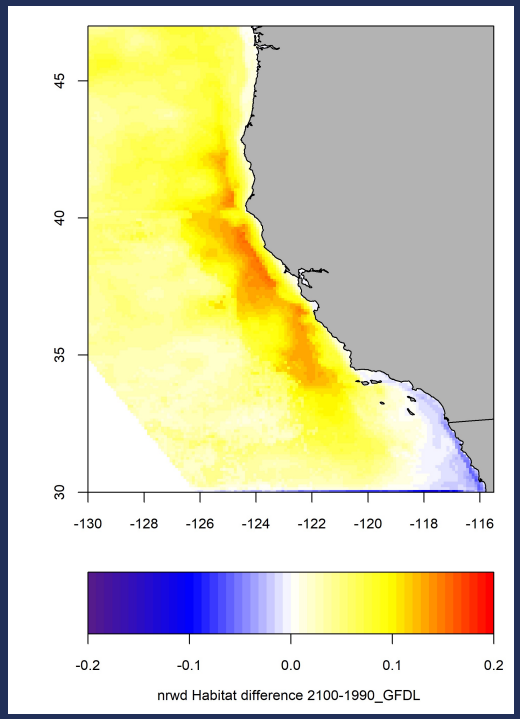
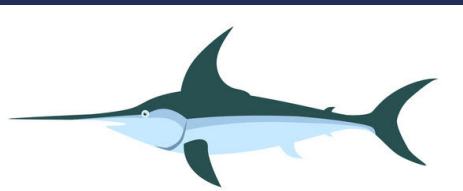
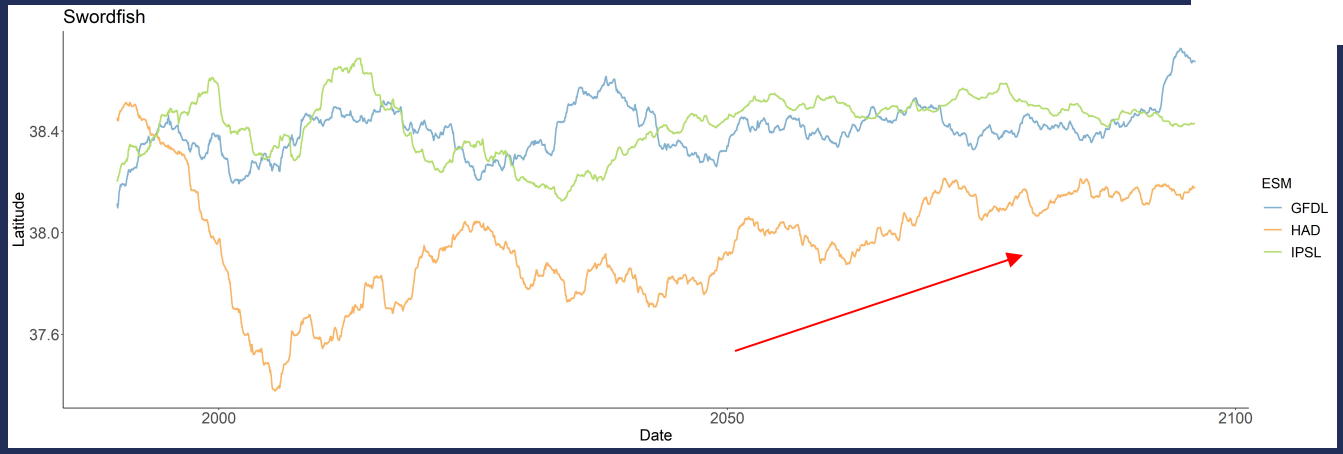


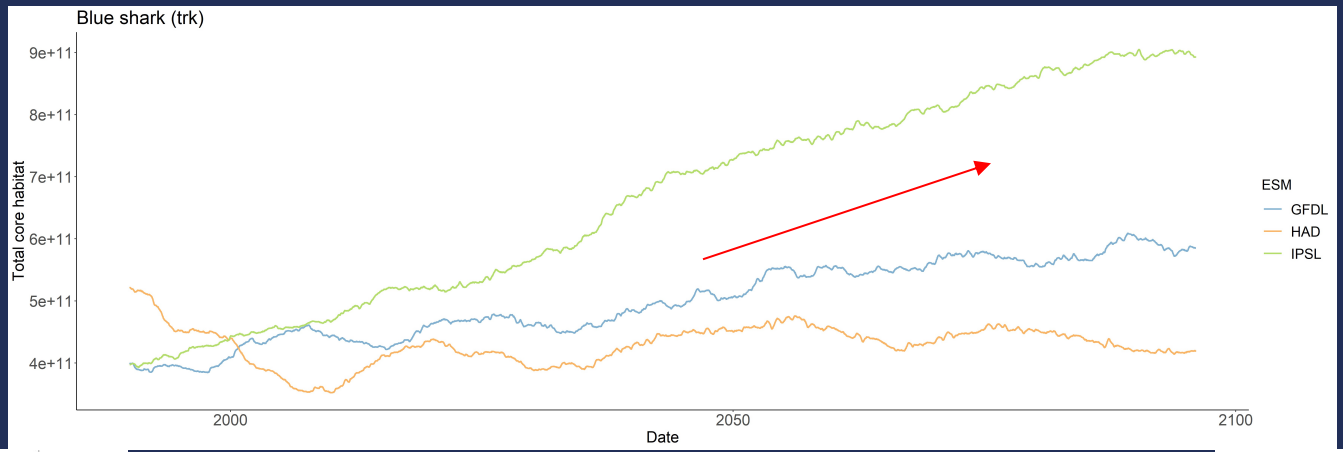
N. Ochoa

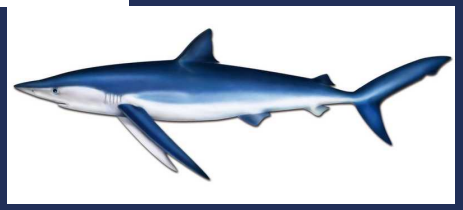
Blue shark

Magnitude / Velocity of Change





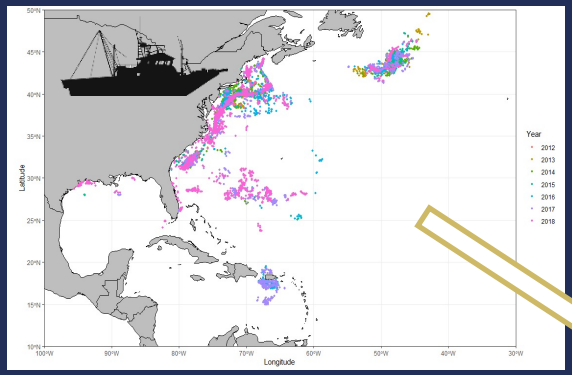




Nerea Lezama Ochoa

Forecasting vessel dynamics

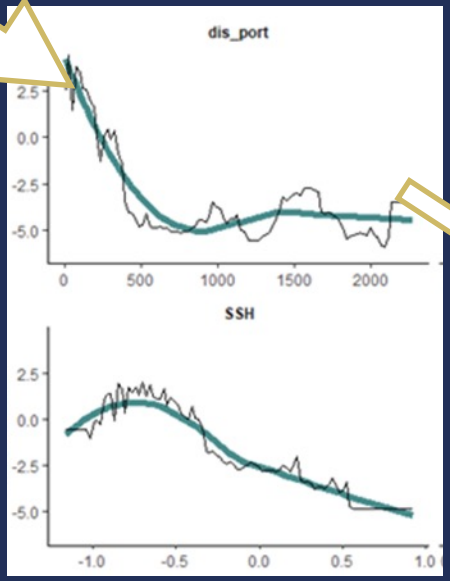
Shipboard AIS >70,000
fishing vessels globally



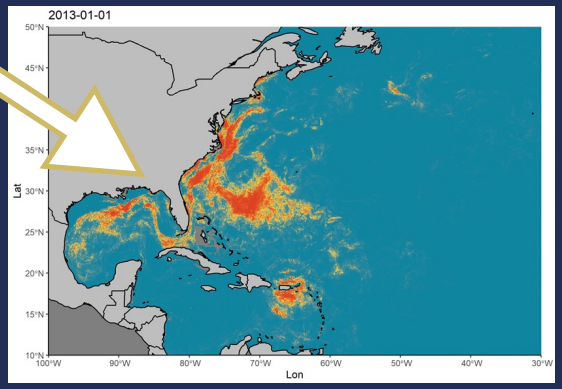
AIS-based movements

GLOBAL FISHING WATCH

dVDMs

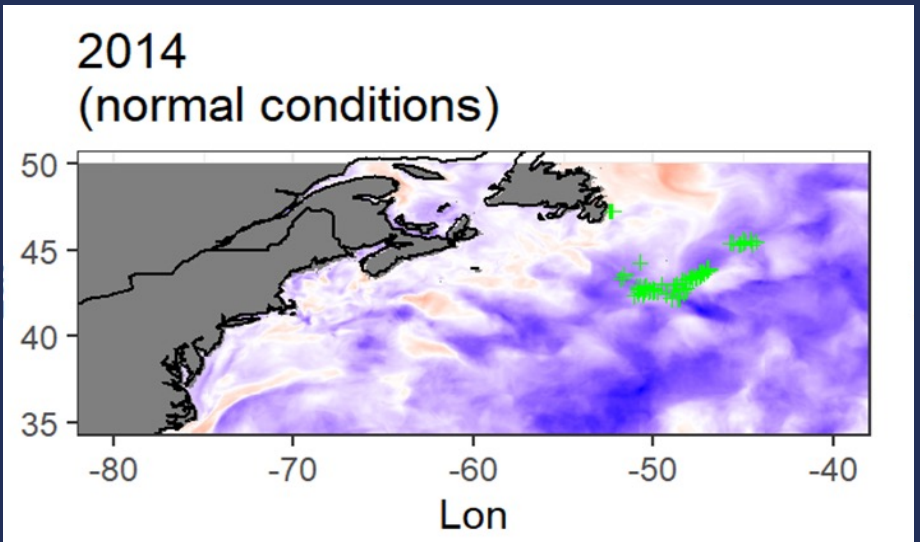


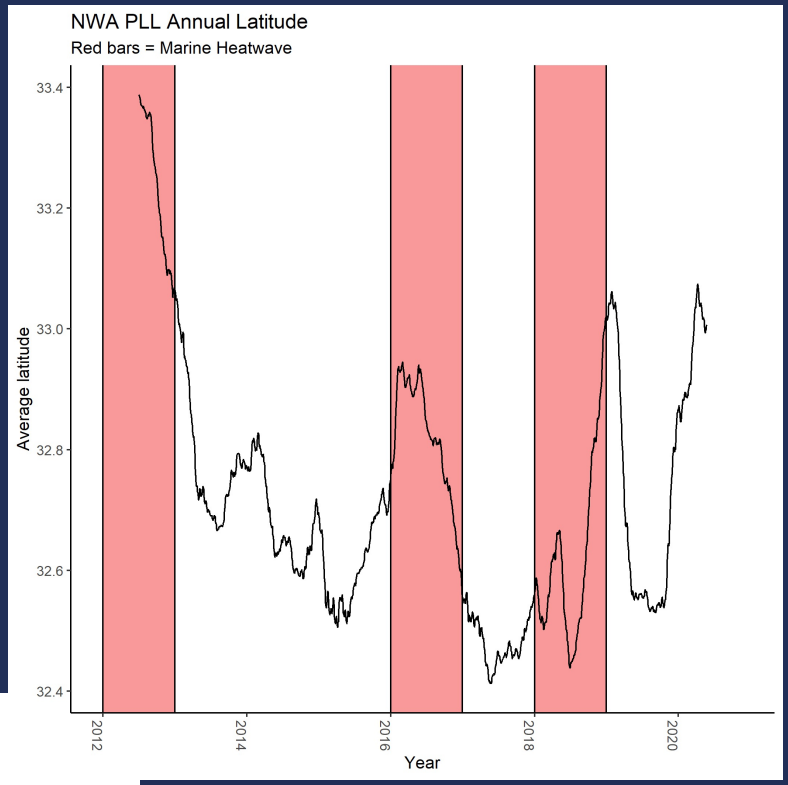
Predicted vessel distributions

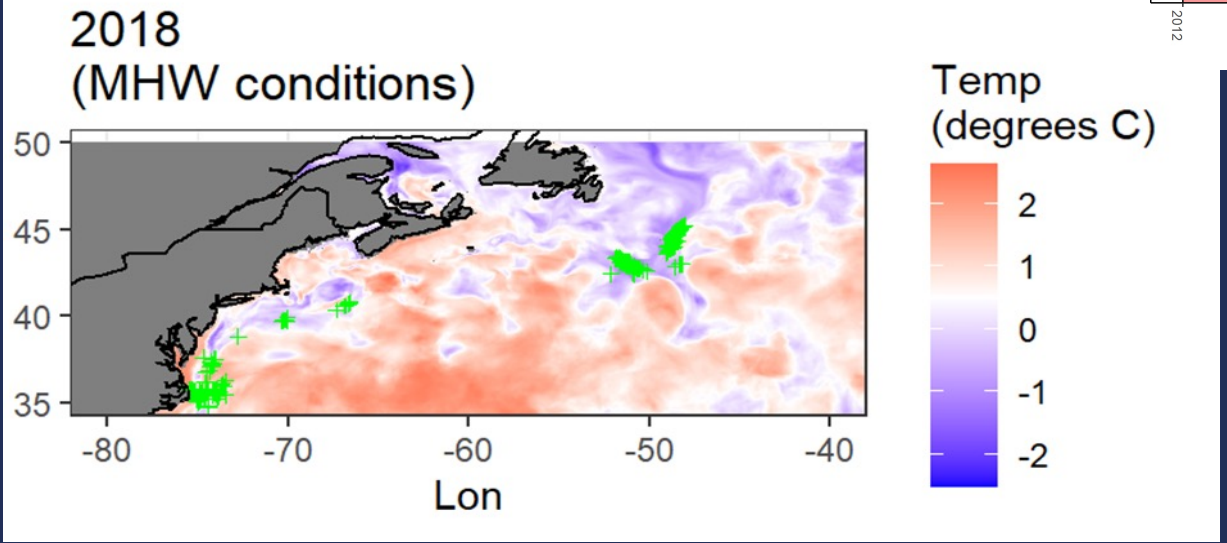


Nima Farchadi

Magnitude / Velocity of Change





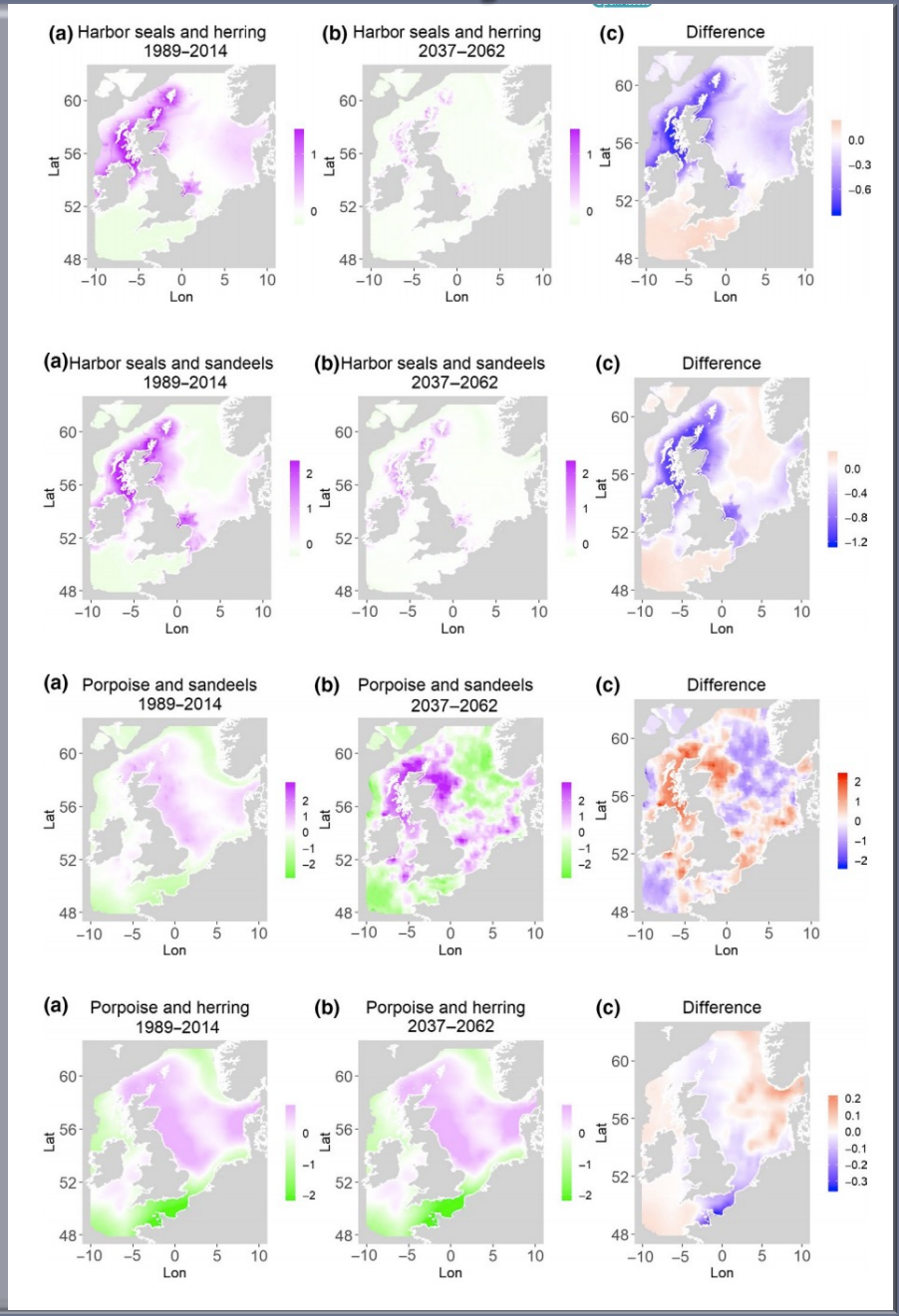


Forecasting species and vessel dynamics

Joint distribution modeling:

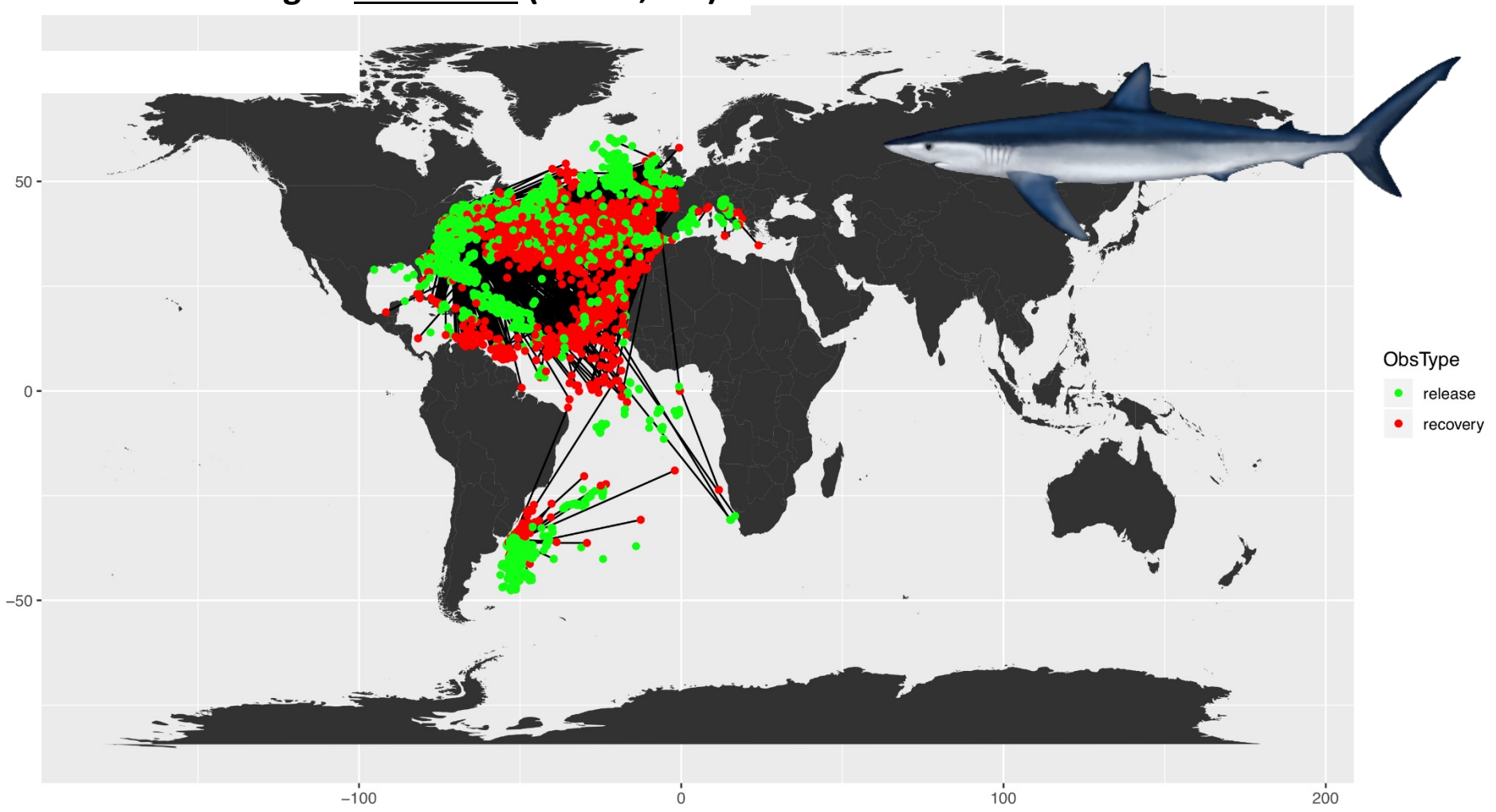
Comparing present and future climate-influenced distributions

(*sensu* Sadykova et al. 2016, 2019)



Harnessing big data/Computing

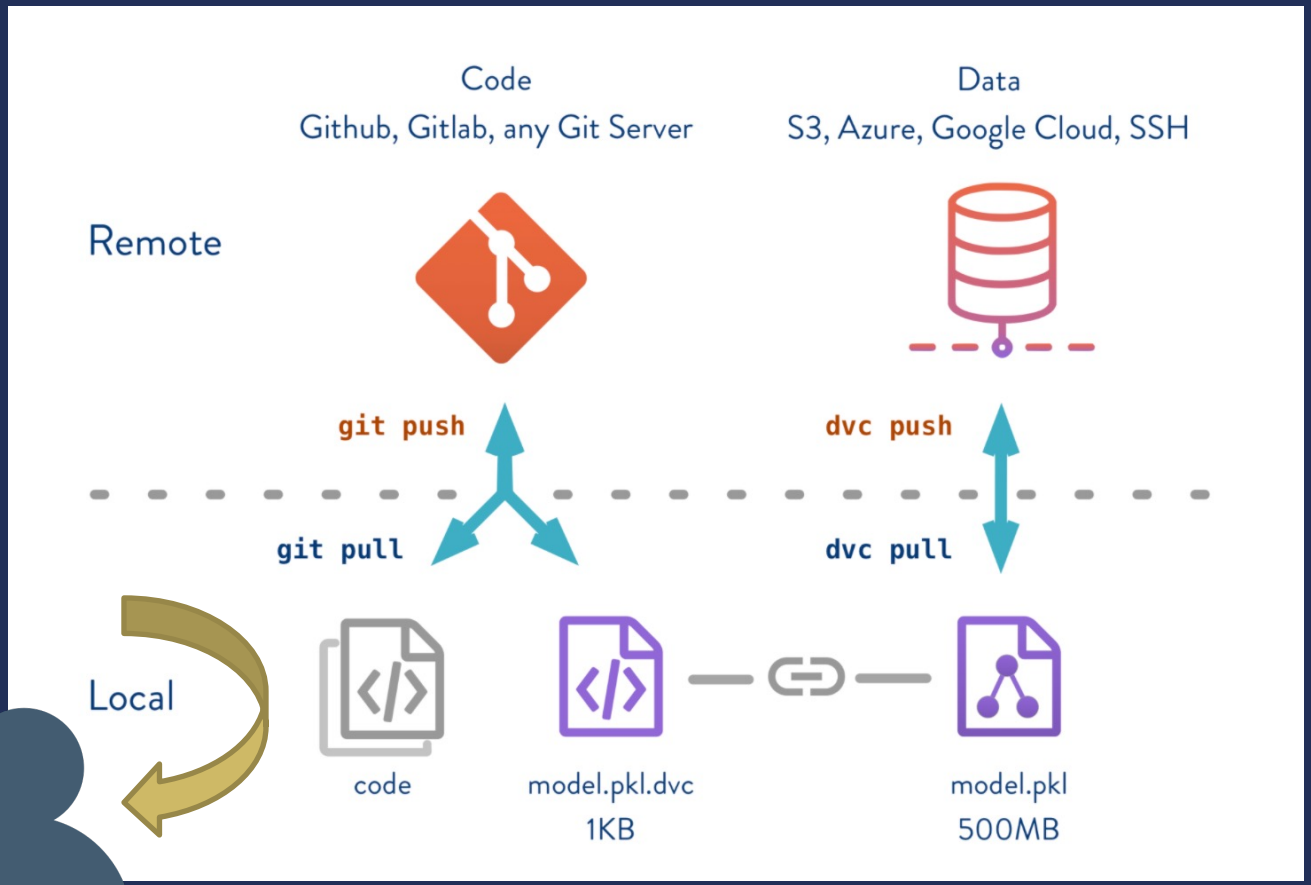
ICCAT marker tags – blue shark (N = 96,175)



NW Atlantic (N = 194,756) | Total ICCAT (N = 484,065)

Building better models by integrating “big” datasets

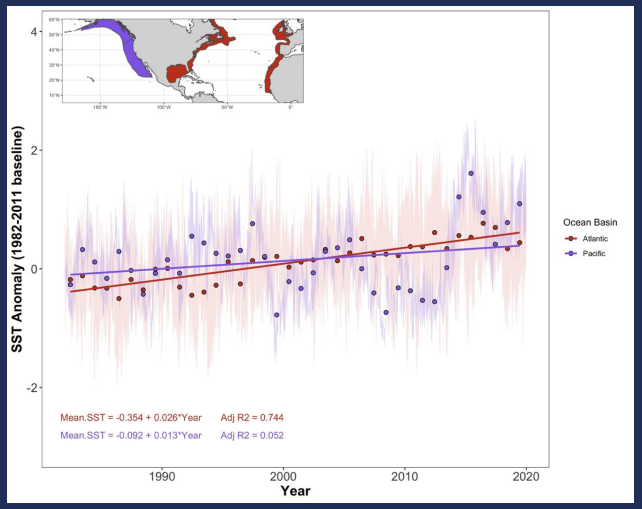
From big data to decision support: an end-to-end machine learning workflow



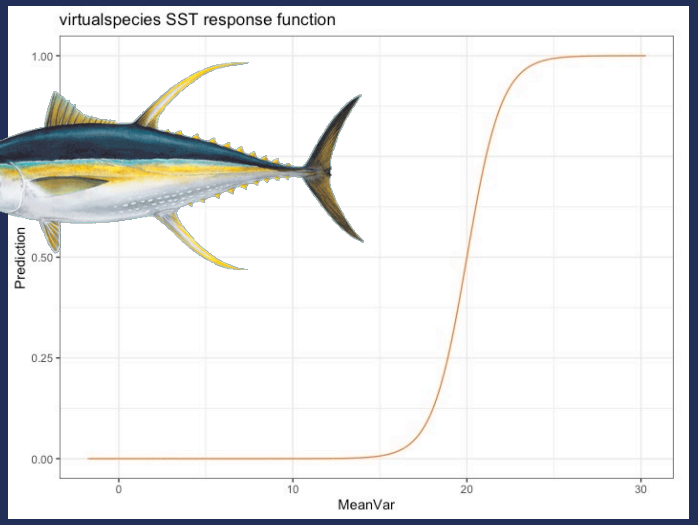
DAGSTER DVC aws GitHub R docker

Communicating/Unpacking Uncertainty

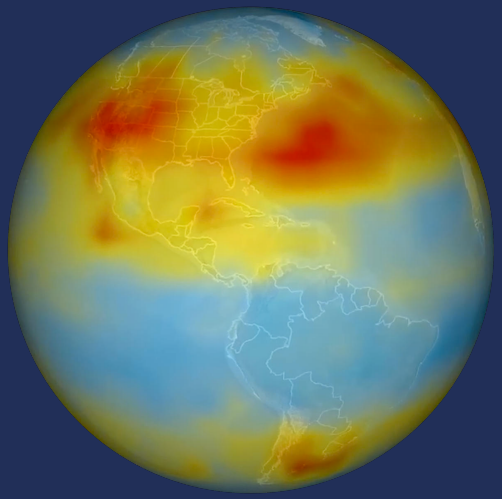
Underlying ocean dynamics



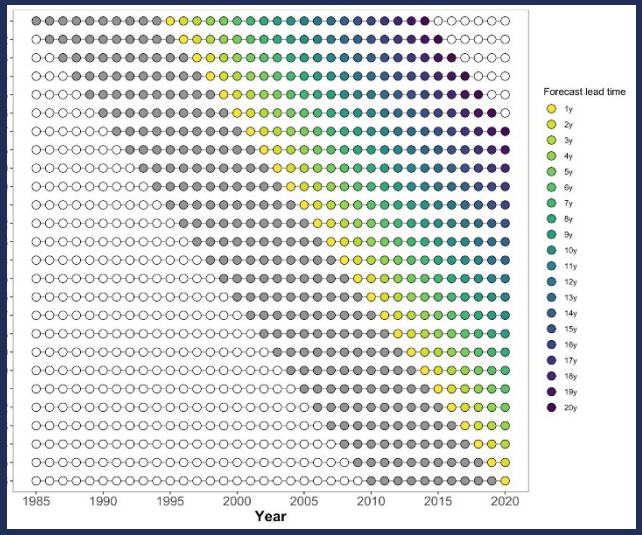
Species traits



Climate models



Amount of data



FORECASTING SKILL OF SPECIES DISTRIBUTION MODELS ACROSS LARGE MARINE ECOSYSTEMS WITH UNIQUE RESPONSES TO RECENT CLIMATE CHANGE

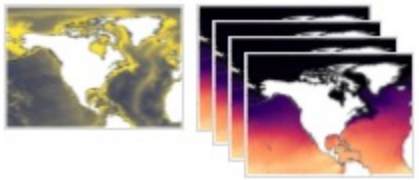
I. SIMULATE SPECIES OCCURRENCE

II. FIT DISTRIBUTION MODEL

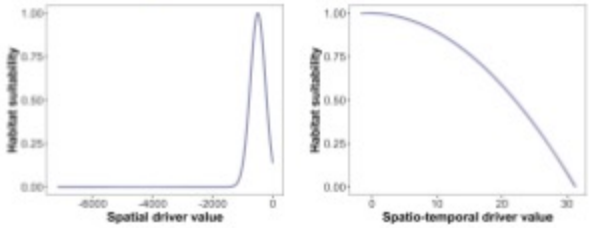
III. FORECAST SPECIES OCCURRENCE

1. Select drivers

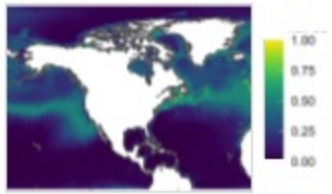
Spatial? *Spatio-temporal?*



2. Set species-driver response curves

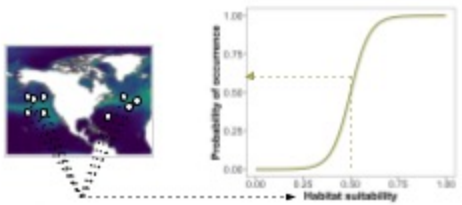


3. Calculate habitat suitability



Suitability = A*spatial driver value + B*spatio-temporal driver value

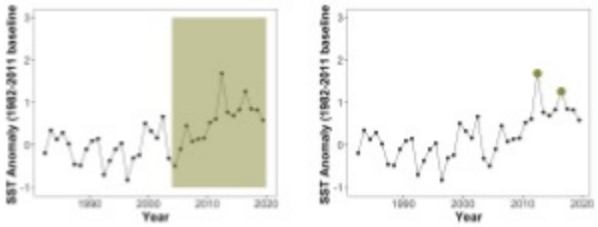
5. Sample locations, transform habitat suitability into presence/absence



P/A ~ Binomial(n = 1, prob = prob of occurrence)

6. Select forecast scenario

"Standard" forecast? *Anomalous events?*

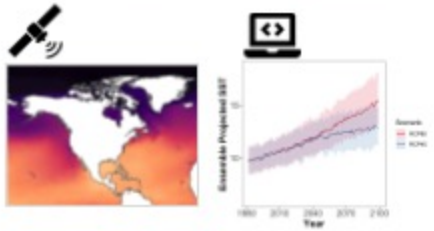


7. Select distribution modeling approach and fit model to training data

GAM? *VAST?* *BRT?*

8. Gather "future" environmental conditions data

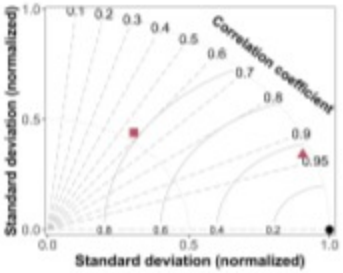
Observations? *Model products?*



9. Make forecast under "future" conditions using fitted model

"Future" conditions → Fitted SDM → Forecasted habitat suitability

10. Compare forecast to null persistence forecast model and validate predictive skill

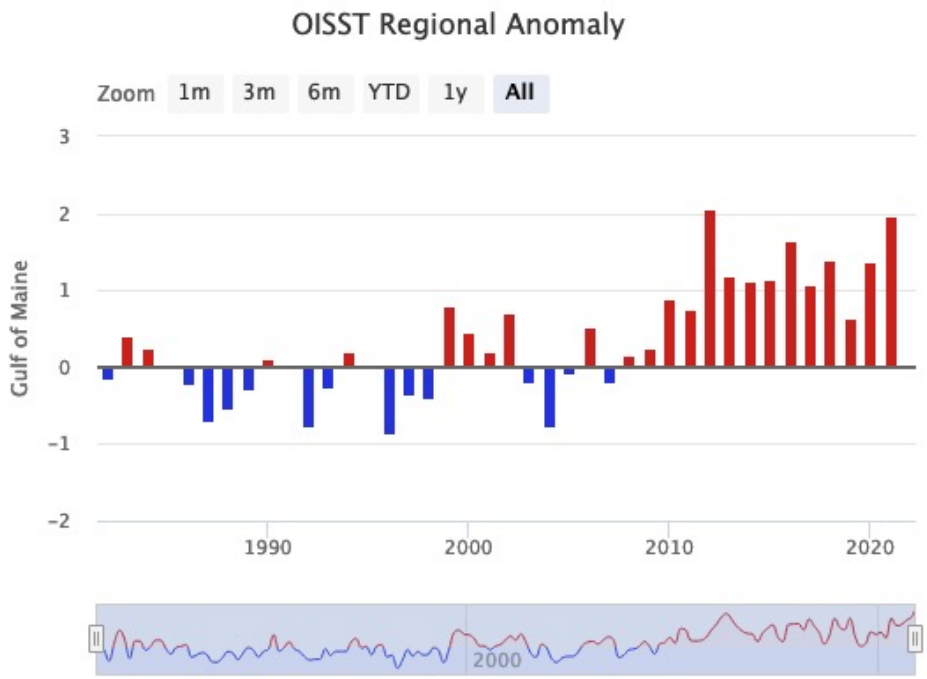


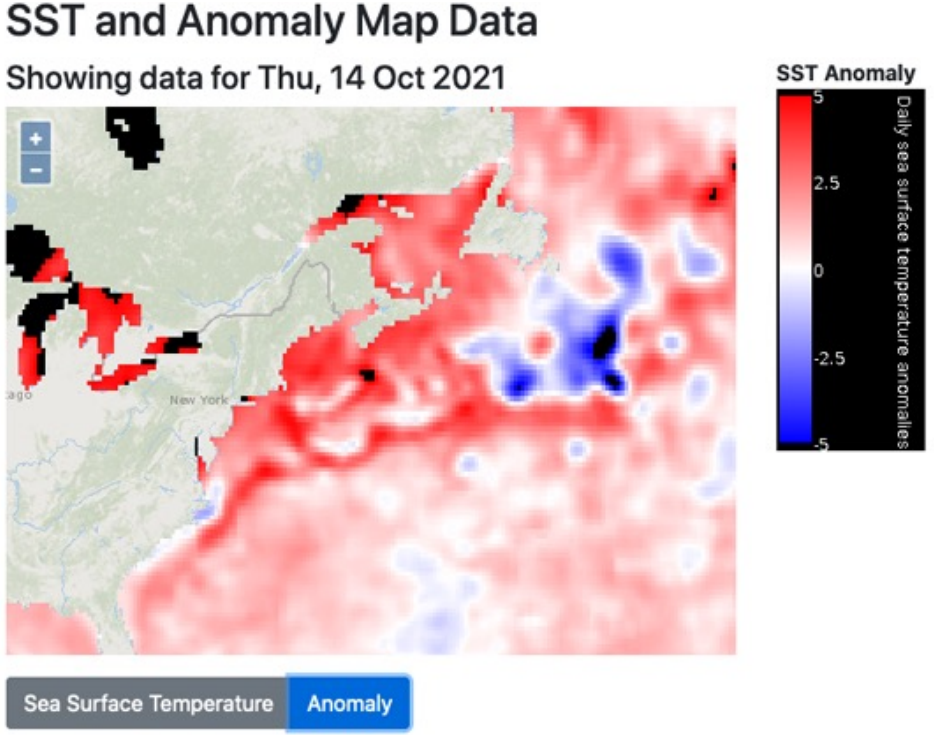
Andrew Allyn

Steph Brodie

Fisheries and Climate Data

SST Climatologies ▾ | SST and Anomaly Map Data | Regional Outlooks/Advisories | About





Riley Young-Morse

Gulf of Maine Research Institute

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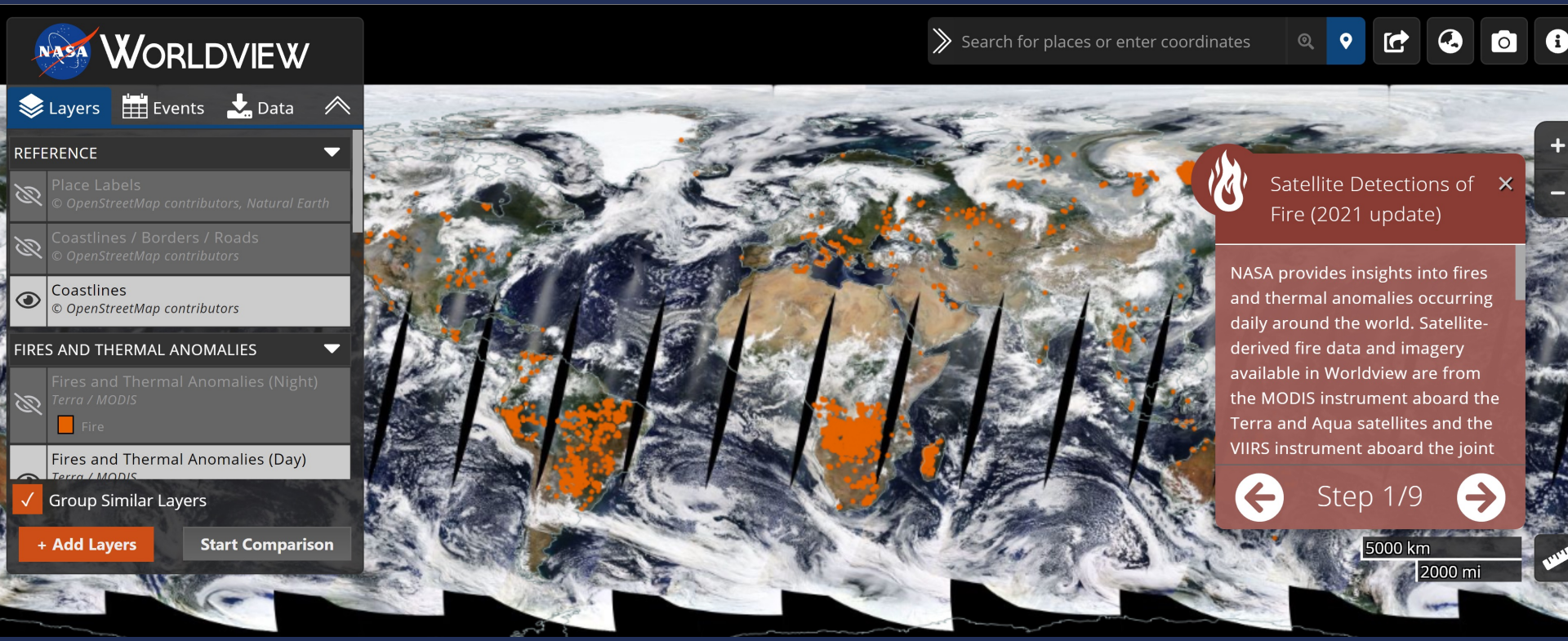
PROJECT

Climate and Fisheries Data Dashboard

Worldview: inspiration for effective communication & storytelling



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Climate models being considered

Models	Scale	Region	Projection or Forecast	Biogeochemistry	Horizontal Resolution - Ocean
CMIP5 ensemble	Global	Global	Projection	Yes	100-km
CMIP6 ensemble	Global	Global	Projection	Yes	25-km to 100-km (ESMs coarser)
ROMS	Regional		Projection	No	7-km within ROMS domain
ROMS-COBALT	Regional		Projection	Yes	7-km within ROMS domain
CM2.6	Global	Global	Projection	No	10-km
Chen et al. 2021	Regional		Statistical Forecast of ocean bottom	No	8-km
RTOFS/HYCOM	Global	Global	Dynamic Forecasts	No	8-km
New NMME (GFDL SPEAR included)	Global	Global	Dynamic Forecasts	No	Varies
MOM6-COBALT - NW Atlantic	Regional		Hindcasts, Forecasts, Projections	Yes	7-km
GLORYSv12	Global	Global	Hindcast (1993-2019)	No	8-km
ROMS	Regional		Hindcast (1970-2015) multiple runs	No	7-km
ROMS-COBALT	Regional		Hindcast (1980-2015)	Yes	7-km
SODA	Global	Global	Hindcast (1869-2010)	No	50-km
SODA (all runs)	Global	Global	Hindcast (varies)	No	Varies
HYCOM	Global	Global	Hindcast (varies)	No	Varies
FVCOM	Regional		Hindcast (1978-present)		
ROMS coarse	Regional	California Current	Reanalysis and operational NRT	No	10-km
ROMS fine	Regional	California Current	Reanalysis and operational NRT	No	3-km
ROMS downscaled	Regional	California Current	Projection	Yes	10-km
WCOFS	Regional	erican West Coast (18-56 c	Operational nowcast and forecast	Yes	4-km

GLOBAL MODELS

Product	Type	Forecast	Spatial Resolution	Time Series	Temporal Resolution	Strengths
HYCOM	DAM	3 months	0.08° x 0.08°	1992 – Present	Daily	Nowcast/hindcasts
NMME	Seasonal	12	1° x 1°	2016 - present	Daily/6 hrs	Seasonal forecasts

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SODA	Global	Global	Hindcast (1869-2010)	No	50-km
SODA (all runs)	Global	Global	Hindcast (varies)	No	Varies
HYCOM	Global	Global	Hindcast (varies)	No	Varies
FVCOM	Regional		Hindcast (1978-present)		
ROMS coarse	Regional	California Current	Reanalysis and operational NRT	No	10-km
ROMS fine	Regional	California Current	Reanalysis and operational NRT	No	3-km
ROMS downscaled	Regional	California Current	Projection	Yes	10-km
WCOFS	Regional	erican West Coast (18-56	Operational nowcast and forecast	Yes	4-km

Product	Forecast	Spatial Extent	Spatial Resolution	Time Series	Temporal Resolution	Strengths
UCSC CCS	Daily Seasonal (coming soon)	Eastern Pacific	0.1° X 0.1°	1989 – Present	Daily	Nowcasts/hindcasts, Seasonal forcasting TBD
ESPreSSO	Daily	Mid-Atlantic Bight (Cape Cod -Cape Hatters	0.6° X 0.6°	2013-present	Daily	Nowcasts

Species data (example)

Species	Data Type (add more rows if needed)	basin	Time-series	Seasonal Coverage	Spatial Extent	Lifestage	Contact Person(s)	comments and notes
Shortfin mako Shark	Observer	pac	1990-current	Sep-Jan	California Current	Adults and Juveniles	NOAA/ERD	
Shortfin mako Shark	Observer	atl	?	?	?	Adults and Juveniles	NOAA HMS; Dan Crear	scrub positions and fishery
Shortfin mako Shark	Telemetry	pac	tbd	tbd	California Current	sub adults to adults	NOAA: Heidi Dewar	
Shortfin mako Shark	Telemetry	atl	tbd	tbd	GMx; NWA	sub adults to adults	Cam has adults and access to sub adults in NWA; a	
Shortfin mako Shark	Conventional Tag	atl	tbd	all	NAtl; GMx	all	Cam	ICCAT c-tag database
Blue Shark	Observer	pac	1990s-2016	full year	Eastern pacific		NOAA/ERD	
Blue Shark	Observer	atl	?	full year				
Blue Shark	Telemetry	pac	tbd					TOPP
Blue Shark	Telemetry	atl	~2015 on	all	NWA	adult	Cam	Steve Campana has lots of
Blue Shark	Conventional Tag	pac	late 2000s?	full year	Eastern pacific	all	NOAA/ERD	
Blue Shark	Conventional Tag	atl	late 2000s?	full year	NAtl; GMx	all	Cam	ICCAT c-tag
Yellowfin Tuna	Observer	pac	1990-current	Sep-Jan	California Current	Juveniles	NOAA/ERD	Data is limited (not target s
Yellowfin Tuna	Observer	pac	?	?				IATTC?
Yellowfin Tuna	Telemetry	pac						TOPP?
Yellowfin Tuna	Telemetry	atl						Kneebone in NWA
Yellowfin Tuna	Conventional Tag		tbd	all	NAtl; GMx	all	Cam	ICCAT c-tag
bigeye tuna	Observer							
bigeye tuna	Telemetry	pac						check NMFS Pacific Island
bigeye tuna	Telemetry	atl	tbd	fall, winter, spring	NAtl	sub adults and adulst	Cam	Lam/Lutcavage has NW At
bigeye tuna	Conventional Tag	atl	tbd	all	NAtl; GMx	all	Cam	ICCAT c-tag
Swordfish	Observer	pac	1990s-2016	full year	Eastern pacific		NOAA/ERD	
Swordfish	Observer	atl	tbd					NOAA HMS / SEFSC
Swordfish	Telemetry	pac						Pac Islands Ctr? Dewar?
Swordfish	Telemetry	atl	late 2000s on	all	NAtl	sub to adult	Cam; Kerstetter	Cam owns some; several c
Swordfish	Conventional Tag		tbd	all	NAtl; GMx	all	Cam	ICCAT c-tag

EcoCast species -> leatherback, sea lion, blue shark, swordfish, risso dolphin, northern right whale dolphin, short beak common dolphin, pacific white sided dolphins, shortfin mako shark, common thresher shark

Environmental data

Variable	Type	Product	Satellite or ROMS	Forecasting?	Spatial Resolution	Spatial Extent	Time-Series
Temperature at depth	dynamic	HYCOM	data assimilating model	7d forecast	0.08	global	1992 to present
sea surface temperature (SST)	dynamic	HYCOM	data assimilating model	7d forecast	0.08	global	1992 to present
sea surface temperature (SST)	dynamic	OI SST	remotely sensed	NA	0.25	global	1982 to present
sea surface height (SSH)	dynamic	HYCOM	data assimilating model	7d forecast	0.08	global	1992 to present
surface currents (u and v)	dynamic	HYCOM	data assimilating model	7d forecast	0.08	global	1992 to present
salinity	dynamic	HYCOM	data assimilating model	7d forecast	0.08	global	1992 to present
brunt-vaisala frequency (N2)	dynamic derived	from hycom depth, temp, salinity	data assimilating model	7d forecast	0.08	global	1992 to present
EKE	dynamic derived	from hycom u,v	data assimilating model	7d forecast	0.08	global	1992 to present
SST_sd	dynamic derived	hycom sst	data assimilating model	7d forecast	0.08	global	1992 to present
SSH_sd	dynamic derived	hycom ssh	data assimilating model	7d forecast	0.08	global	1992 to present
isothermal layer depth	dynamic derived	HYCOM	data assimilating model	7d forecast	0.08	global	1992 to present
Bathymetry	static	ETOPO1	na	NA	0.01	Global	na
Rugosity	static derived	from etopo bathy	na	NA	0.01	Global	na
distance to port	static	geolocated relevant ports and applied distance to point function from the raster package	NA	NA	0.08	NWA but can be made to global	NA
distance to seamount	static	Derived from Yesson et al., (2011)	NA	NA	0.08	global	NA
SSTa							
SLA	dynamic	CMEMS	remotely sensed	NA	0.25	global	1992 to present
lunar illumination	static	function "lunar.illumination" in R					